Renew. Energy Environ. Sustain. 7, 20 (2022)
© R. Haas et al., Published by EDP Sciences, 2022
https://doi.org/10.1051/rees/2022009

Renewable Energy and Environmental Sustainability

Available online at:
www.rees-journal.org

Research Article

Open Access

Heading towards democratic and sustainable electricity systems – the example of Austria

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Received: 19 July 2021 / Received in final form: 24 April 2022 / Accepted: 27 April 2022

Abstract. In recent years rising quantities of electricity generated from new variable renewable energy sources (VRES) have influenced the structure of electricity markets in many countries. The major aim of this work is to investigate the conditions required to head towards a sustainable and more democratic electricity supply system by using even higher amounts of VRES for the example of Austria. The most important result of this investigation is that an approach based on market principles – including flexibility and the final customers – is favourable and will ensure that competition at the service level rather than capacity payments will be the basis for future market designs of the electricity system. The transformation towards a sustainable and more democratic as well as increasingly competitive future electricity supply system is likely to be based on different paradigms of "new thinking". This means that the fundamental structures of the overall electricity system will change. It will be based on changing from the old inflexible one-way electricity delivery system to a very flexible one with a two or multi-way flow of electricity. Regarding the case study of the Austrian electricity system the major finding is that up to 2030 RES can contribute to electricity generation to the same extent as electricity demand is expected to be. This implies a growth to about 16 TWh Wind (in 2020: 7 TWh) and 12 TWh PV (in 2020: 1 TWh). However, to meet demand on an hourly base over the whole year even after having implemented additional storage capacities and several flexibility measures on the demand-side an amount of about 2 TWh electricity (compared to 10 TWh in 2019) has to be generated from different gas-based power plants (e.g. natural or biomass-based gases).

1 Introduction

In the history of electricity systems in different countries different boundary conditions were implemented and exist regarding the organization of the electricity systems as well as the market structures. After a long time of strict regulation of the industry by the public in Europe and other Western countries in one or the other way restructuring of the system with the implementation of wholesale electricity markets took place. Today, the system faces the next big challenge: the change towards a bi- or even multivalent system, which should finally bring about a more democratic and sustainable supply with electricity-based energy services. The major reason is that today in real life more and more citizens state their interest in becoming at least partly self-suppliers and participating actively in the system. This process is currently under way in several countries such as Germany, Austria, Denmark, California, Australia and others. In addition, in these countries the principle of how the wholesale as well as retail prices come about has already started to change.

Yet, over the longest period of time the electricity system has been determined by the generators. Until the mid-1990 s, and in many countries even longer, large generation companies, which were often highly vertically integrated, dominated the electricity system. This was supported by the assumption of existing economies-of-scale. Large power plants, mainly coal and nuclear, were built following the principle "the bigger, the cheaper". This approach was accompanied by very large growth rates in demand for electricity.

This solely generation-focused approach was firstly criticised already in the 1970 s by Lovins [1]. He was the first one predicting the following major developments: (i) that future electricity consumption rates would decrease; (ii) that electricity generated decentralized mainly from Photovoltaic systems would become a more important role and (iii) that the relevance of demand-side management would grow. Furthermore, with the liberalization of electricity markets the overall structures of electricity supply egan to change. The core objective of restructuring

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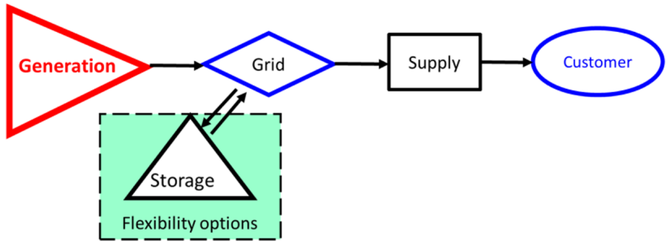

Fig. 1. The principle of conservative thinking in supplying customers with electricity.

in the 1980 s and 1990 s with the focus on liberalization was to implement competition in generation. This sould lead to a maximum of benefits of the electricity system forsuppliers as well as customers. Because of after the first state of liberalisation, a huge quantity of excess capacities was revealed the principle of "prices = short-term marginal costs" was introduced in electricity spot markets.

It is very important to state that in the first phase of restructuring of the electricity supply system the principle of conservative "one-way-thinking" was still fully accepted. That is to say, the producers of electricity were in the centre of this system as well as in the head of the energy politicians, see Figure 1.

The European Union (EU) has introduced ambitious goals for rising the quantity of electricity generated from VRES, e.g. [2]. Actually, in EU-28 countries, in the last years the electricity produced from VRES, e.g. wind and PV, has grown virtually exponentially, with Italy, Spain and Germany providing the largest quantities. In the period 2005–2020 the so-called "new" renewables (without large hydro) with the largest amounts from wind power plants increased from about 2% to around 19% in 2020 (preliminary). For 2030, an overall target of 32% energy provided from renewable energy sources has been set by the European Union. This is a goal for all appllications – transport, electricity and heating. Straightforward, also the amount of electricity produced from PV and wind will increase, as described e.g. in the National Renewable Energy Action Plans (NREAPs), yet, it cannot be foreseen to which amount exactly. Another important intention of this paper is to document what has to be done in market design to integrate all these new additional amounts into the existing electricity supply system.

In Western Europe these high amounts of variable RES have firstly in Germany altered the historical pattern of the electricity system. However, as all other electricity generating power plants – also wind and PV plants do not generate electricity with the same profile as the load develops. Because these renewable capacities generate electricity at Zero costs during many hours over a year have brought about the argument that fossil assets especially natural gas power plants has become less economically feasible because now they run at much less hours over a year. This has led to concerns that plants may be shut down and supply security would be looming. This has brought about the idea of capacity markets completing the existing "energy-only" markets. That is to say, some power plant owners should get money for keeping some flexible power units ready as back-up reserve.

In this paper the following issues with respect to the integration of larger shares of VRES into the Austrian electricity system are discussed:

- Resource adequacy and regulated capacity payments.
- Impact of VRES on the wholesale electricity market prices.
- Reform of the tariff system.
- Request for additional storage systems.
- Need for flexibility measures.
- Integration of the demand-side to obtain complete markets.
- Setting up of a coordinating entity.

This work builds on Auer et al. [3] and Haas et al. [4], and the following three review references [5], [6], and [7] which cover the major issues of electricity market design comprehensively as well as the major literature described in the Section 2.

A very comprehensive review is conducted by Newbery et al. [5]. They discuss the major conditions for a market design with large quantities of VRES in the European electricity markets. They provide a portfolio of specific recommendations for policy makers to ensure the optimal future market design of electricity markets in European countries which will include much higher amounts of wind, and PV ensuring that the renewable targets of European countries' are timely implemented. Their major conclusions are: (i) Various contractual relationships between customers and retailers may be needed, ensuring the financing of long-term investments at reasonable cost and reflect the more distributed nature of generation (ii) amarket design adated to the new challenges may provide incentives for a range of new sources of flexibility; (iii) A completely different future design may emerge from empirical case studies and the development of new technologies.

Bubitz et al. [6] provide a survey on the currently discussed relevance of capacity remuneration mechanisms (CRM) to secure system adequacy. They state that determining the optimal market design, remains an ongoing challenge. As the proper design depends on several factors e.g. the existing capacity mix and the profiles of demand no general benefit of single mechanisms has been found so far. They find that nontheless crossborder aspects are can be different and the results in literature are sometimes controversial, at least a minimal consensus exists that the implementation of CRMs brings about unwanted spillover results on electricity markets in neighboring countries without CRM implemented. Another important conclusion is that compared to an energy-only market (EOM), the value of flexible resources is decreasing in the presence of a CRM. Eventually, y they state that despite a high number of studies has already done, the comparability of the results is very difficult and, hence, it is very difficult to find the best mechanism for specific single cases.

Regarding the issue/integration of decentralized or distributed energy resources (DERs) Tsaousoglou et al. [7] present a nice review on market mechanisms for Local Electricity Markets (LEMs). They calls for aggregating entities which handle the energy management decisions of small DERs and represent these DERs upstream. These decisions are typically envisaged to be made via LEMs and depending on the market mechanisms. In this paper they provide a comprehensive literature survey depending on the objective adopted – social welfare vs profit maximization vs fairness – and the mathematical technique used. Their major finding is that a rising requirement for practically applicable and standardized testbeds to identify appropriate electricity market designs, because several mechanisms documented in literature have been developped for very special modeling applications, and hence are not comparable to each other. The final requirement is to implement different market mechanisms in concrete use cases.

The core objective of this paper is to analyze and provide insights on how to bring about a sustainable and more democratic electricity system where even higher amounts of variable renewable energy sources (VRES) could be integrated for the example of Austria. The target is to document how to reach a economically balanced system in the electricity market, considering all dimensions as there are generation, demand and storage as well as other flexibility options, avoiding escalating interferences by politicians. It is motivated by the recent discussion in which way large shares of VRES should be integrated in the best way but the basic intention goes far beyond that. The major important new aspect of this work is that it applies the theory of designing an electricity market to the country of Austria.

2 Review of major literature

In this section an overview on the major latest works of literature on the topic market design is provided. It can be further categorized into: (i) basic principles of electricity market design, (ii) capacity adequacy (regulatory interventions on the supply-side); (iii) the impact of VRES and how to cope and (iv) Regulatory interventions on the demand-side.

Newbery [8] discusses the future for liberalized electricity markets with focus on whether they are efficient, equitable and innovative. He argues that well-constructed restructuring of the European electricity markets have brought about gains in efficacy yet some political risks of reducing carbon in electricity generation in energy-only markets have reduced the incentives to conduct investments. Newbery [8] further states that the functioning and linkage between supply, grid and retailing firms will largely depend how and to what extent they may obtain the difference of the overall expenses due to the costs and the prices resulting from the short-term marginal costs.

In Grubb/Newbery [9] lessons learned from the UK electricity market reform are presented. They state that the energy-only market central to the EU Target Electricity Model is demonstrably unsuited to cost-effective new investment, while capacity payments could work – if the remaining regulated network tariffs are correctly set. However, they do not provide a sound proof for this statement. They finally state that the challenges of Capacity markets are slowly being resolved, despite Reliability Option auction seems to be the preferable measure as solution, but integrating demand side management options still remains a task for the future.

Astier and Lambin [10] investigate how capacity Adequacy maybe ensured in widely unregulated electricity systems. They analyze electricity markets where an exogenous price cap is enforced with compromising both short-term and long-term incentives. These price caps have been repeatedly criticised for creating a so-called “missing money” problem [11,12]. They state that despite mechanisms that keep implicit these high marginal costs are likely to be preferred from a political perspective they also appear to be less efficient. They suggest to set the price cap higher than the marginal cost of the most expensive plant, and highlight that challenges for demand-response integration in capacity mechanisms remain.

Bucksteeg et al. [13] analyze the impact of un-coordinated vs. international coordinated capacity mechanisms. They argue that in principle the introduction of national capacity payments is not in line with the aim of a European-wide internal electricity market. Their main finding is that capacity markets may have high cross-border synergies and save some costs but has to be coordinated carefully. Otherwise the CM may to severe inefficiencies. The conclusion of their analysis is that that an asymmetric or country-specific introduction of capacity markets in Europe has to be avoided.

Praktiknjo and Erdmann [14] analyze whether renewable electricity and back-up capacities are an (un-)resolvable problem. They argue, incentives should not just be provided to renewable generators but also to measures on the demand-side. They argue that subsidizingboth renewable and conventional capacities simultanuously contradicts every idea of a market-based system. They find that premiums given paid to the players on the demand side (e.g. the retail companies) depending on the quantities of renewables in their portfolios. They pretend that an approach which explicitely considers the demand-side would lead to much higher flexibility and could even include other innovative solutions to integrate even much higher amounts of VRES into the electricity systems. If it would be left to the market forces to bring about the optimal solution for the integration of the variable RES, the idea of competition in providing electricity-based services would be strengthened.

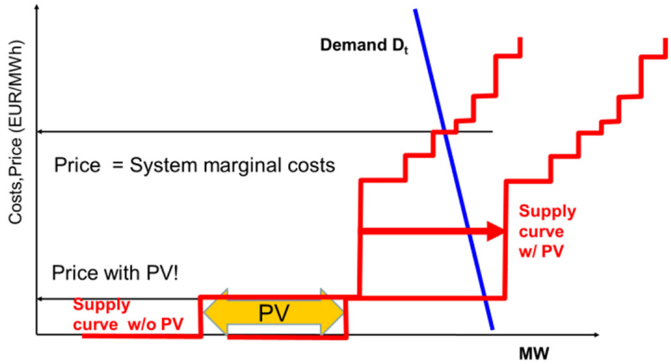

Fig. 2. Merit order electricity supply curve including and excluding significant PV quantities at noon on a sunny day in summer and the additional marginal costs for nuclear, coal and natural gas capacities.

Botterod/Auer [15] compare the US and Europe and investigate resource adequacy planning with increasing shares of wind and solar power. They investigate whether alterations of the existing energy-only markets maybe enough to keep resource adequacy in the power systems or whether the accelerated increase in power from VRES provides additional arguments for extending capacity payments. Their most important finding is that the key to realize an integration of VRES in a way which is compatible with market principles is to put emphasis on short-term price formation as correct as possible. Their major conclusion is that a growing dependence on capacity payments would turn the electricity supply back to the planned economy that was dominating before the start of the restructuring of the electricity industry in the early 1990 s.

Neuhoff et al. [16] investigate the European lessons learned regarding power market design development with increasing quantities of VRES. They state that system operation and short-term pricing mechanisms have to considerthe different needs of conventional as well as renewable generators and the different flexibility options.

Pownall et al. [17] discuss a re-design of UK's electricity market design with focus on considering the value of distributed energy resources. They suggest a revised local coordinating and balancing system located at every network node and the introduction of a distributed locational marginal pricing structure which should be organized by the distribution grid company.

The prospects for larger amounts of VRES electricity generation in Ireland are analyzed in Lynch et al. [18]. In a qualitative review their major finding is that a new market design should to address price cannibalisation, consider consumer preferences and especially protect vulnerable low-income households.

Summing up, the following issues are of core relevance: (i) very different new contractual relationships between electricity consumers and retailers are required may be under the head of a new coordinating entity; (ii) regulated capacity payments have to be introduced very cautious; (iii) storage and other flexibility measures will play an increasingly relevant role; (iv) a new tariff design at the final customers level is of core relevance; (v) however, the integration of VRES will not interfere the fundamental principle that all resources and externalities have to be priced in the markets in an adequate way.

3 The impact of variable renewables on prices in electricity spot markets

The first issue of interest is how the prices in European wholesale electricity markets developed with special focus on the impact of the variable renewables. To identify the impact of variable RES on the prices in wholesale electricity markets it is important to understand how prices in European electricity markets currently come about, see [3].

In this context it is important to look at the historical dynamics. The restructuring of electricity supply began in European countries at the end of the 1980s in England and slowly moved to other European countries. A core milestone was the introduction of a directive of the European Union on joint rules for a common EU-wide market for trading electricity [19]. The most important aspect was that the way how electricity prices come about changed. In the former regulated electricity systems, tariffs were set without considering the underlying marginal production costs. These fixed tariffs were obtained, by dividing the overall costs of electricity generation, transmission and distribution by the quantity of electricity sold considering differences among various categories of customers, e.g. households and industry. The major change after the first wave of liberalization was that wholesale electricity market prices were now expected to equal the marginal costs of production of electricity. That is to say, the price in the wholesale market resulted now from the intersection of demand and a merit order curve representing the supply curve – at every hour (or now even quarter of an hour), see [20] and Figure 2. In addition, at the time when liberalization started, huge excess capacities existed in Europe which were already depreciated. This led to the expectation that prices should from now in every hour be equal to the short-term marginal costs (STMC) as illustrated in Figure 2.

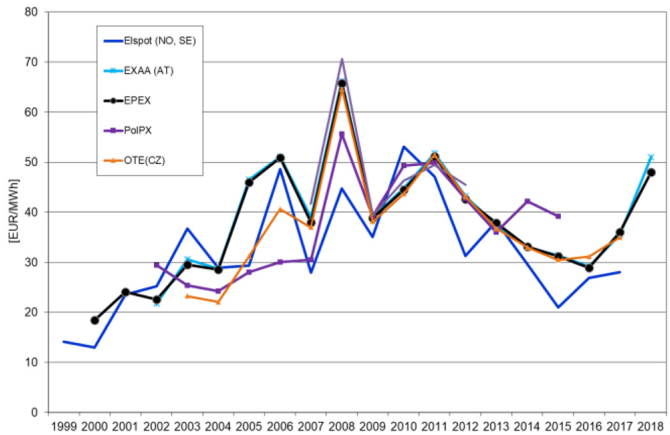

Fig. 3. Development of wholesale electricity prices on various European spot markets (day-ahead) (from 1999 to 2018).

The major historical energy sources for electricity production in Western Europe were fossil, nuclear and run-of-river power stations. In the EU-28 countries since the 1990 s, most often nuclear provided the highest amounts, followed by coal, hydro and natural gas. The VRES did not provide significant quantities until recently. However, since about the year 2015 renewable electricity from hydro, wind, PV and biomass contribute the largest share in the EU-28.

Over the period 2011 to 2016 almost continuous decreases of spot market prices at the Western and Central European electricity exchanges took place, see Figure 3. This is also true for the example of Austria which is the specific focus of this paper. The most important reason for this price decrease was the continuous growth of wind and PV plants with short-term marginal costs of Zero. This rise in VRES has influenced spot market day-ahead prices, the patterns of electricity trading as well as the dispatch of natural gas and coal generation since 2011. The explanation is simple. Assume a sunny day with a lot of solar electricity produced. In this case the supply curve is moved to the right and as depicted in principle in Figure 2, may even completely push coal and natural gas electricity production out of the market [21].

How VRES affect electricity prices is known from fluctuating hydro power in the Nordic European electricity market, and since the early 2000 s in Denmark with temporarily high quantities of wind, see e.g. [22].

4 A scenario for the example of Austria up to 2030

In the following the example of a BAU-scenario for electricity generation and demand in Austria is shown (including natural hydro storage with and without pumped storage). In this scenario demand up to 2030 will be met with 100% RES in 2030 (balancing principle). Data up to 2019 are historical data. A special issue is in detail to analyze the impact of the aggregated quantity of all variable RES on the wholesale electricity prices on various European spot markets from the above-described effects, electricity generated from wind or PV plants also has an impact on the marginal cost at which electricity generated from natural gas is bed at the exchange. Straightforward, in markets with high quantities of VRES, such as hydro, wind, PV the relevance of conventional capacities is different see e.g. [14,20,23].

The dynamics of overall generation and demand in the BAU scenario up to 2030 (including shares of natural and pumped storage) is shown in Figure 4. A major boundary condition is that overall electricity generation from all types ofrenewables by 2030 has to be equal to overall electricity demand where also the electricity needed for pumped hydro storage is included. This results in an equilibrium value of 78.5 TWh. Additional amounts to be generated from RES are: 5 TWh produced from hydro power plants, 10 TWh from wind power 11 TWh generated by PV plants, and 1 TWh from biomass,) see also [24,25]. Figures 4–6 present the main plots in the BAU scenario for 2030. A monthly balance of electricity generation and demand in 2030 is shown in Figure 5. Since of relevance in Austria, this graph informs also on the demand and supply from pumped storage hydropower plants. Figure 6 shows the development of installed capacities und yearly peak load (in MW) in the BAU-scenario from 2015 to 2030 (incl. capacities of hydro storage), see also [24,25].

Figure 7 depicts the development of load vs electricity generation from variable RES such as wind, PV, run-of-river hydro and hydro storage in Austria over a week in winter 2030 on an hourly base. As seen there is no hour where the VRES can meet over-all demand. Flexible back-up capacities e.g. gas power plants are required to meet the load. Figure 8 illustrates the corresponding development of VRES vs demand over a week in summer. In this figure it is obvious that the periods of under coverage and excess generation change very oftenand hence the need for storage is obvious.

This leads to the following categories of presumed “problems”: (i) Prices may finally be even negative in some hours specifically during summer months; (ii) revenues to cover the fixed costs for flexible back-up power plants, e.g. based on natural gas may be to low to be operated without losses. Yet, today it is not foreseeable how many hours these low prices will exist.

For the residual load shown in Figure 9 a price pattern as described in Figure 8 may emerge.

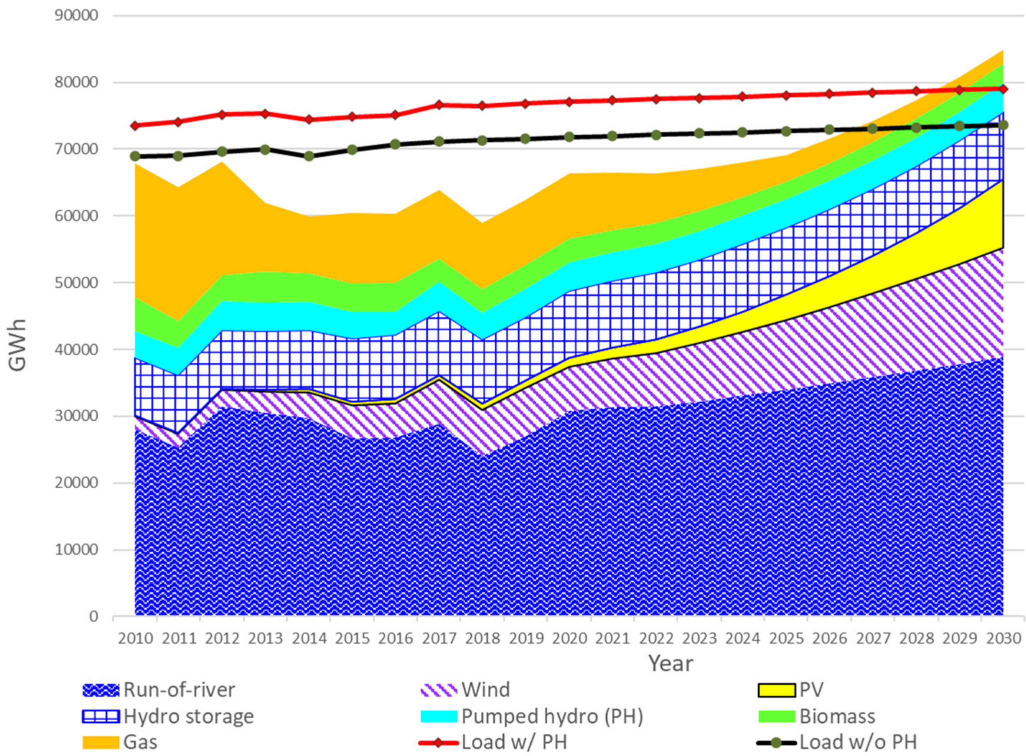

Fig. 4. Electricity generation and demand in Austria (w/ and w/o pumped hydro (PH) storage) in a BAU-Scenario up to 2030 with 100% RES in 2030 (balancing principle) in GWh/year.

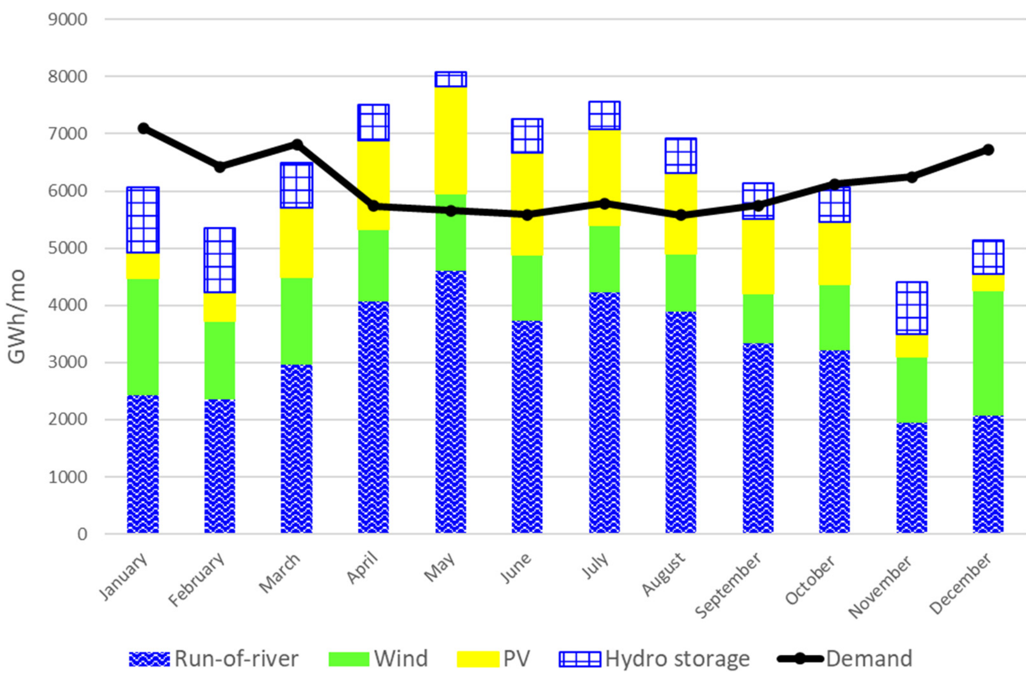

Fig. 5. Electricity generation and demand in Austria (w/o without pumped storage) in a BAU-Scenario on a monthly base with 100% RES in 2030 (balancing principle) in GWh/month.

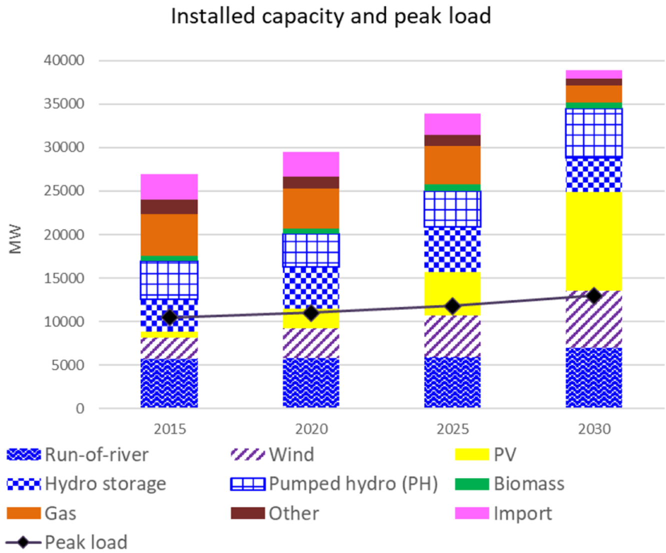

Fig. 6. Development of installed capacities und yearly peak load (in MW) in the BAU-scenario from 2015 to 2030 in Austria (incl. capacities of hydro storage).

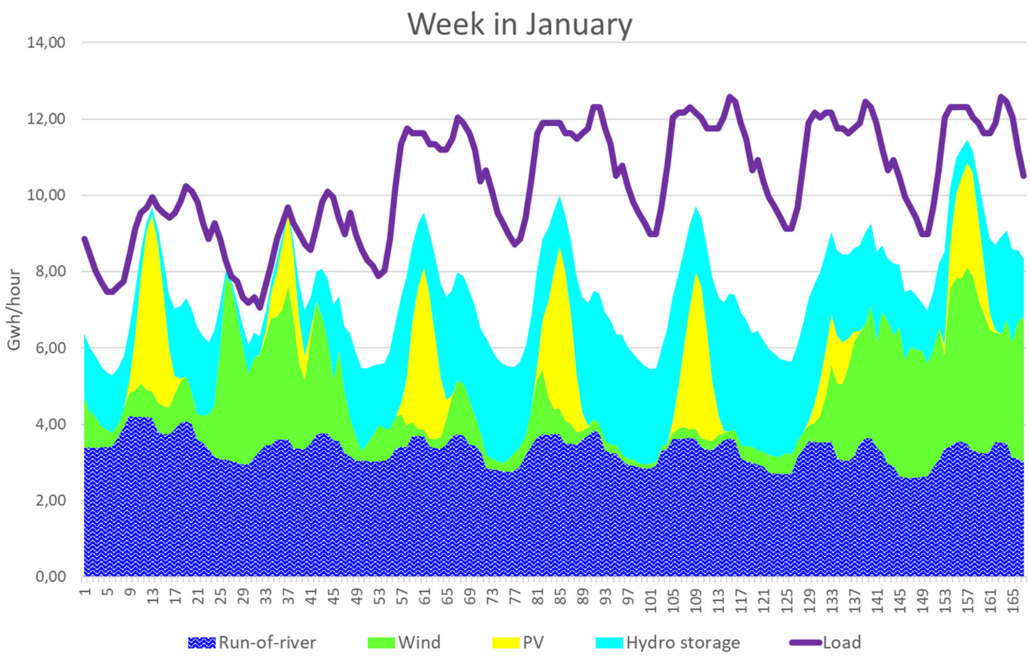

Fig. 7. January 2030: Modeling variable renewable energy sources, and electricity load during a week in 2030 in winter in Austria.

5 Flexibility: the key term of the future

Flexibility options such as storage, technical DSM (e.g. cycling) or demand response via price signals (e.g. time-of-use-tariffs) are well-known already since decades. However, with the exception of pumped hydro storage they have so far not received muc attention for balancing supply and demand. The major reason is that still today in most countries the final customers do not get any proper price signal.

If there would be price signal as correct as possible in both, wholesale and retail markets the options of flexibility would contribute in a competitive way to decrease high price spikes and straightforward lead to new balances between supply and demand. In addition, it is necessary that market signals on the demand-side have to be developed. Up to now, customers have not been asked regarding how they appraise the value of capacityand which price they would be ready to pay for that capacities.

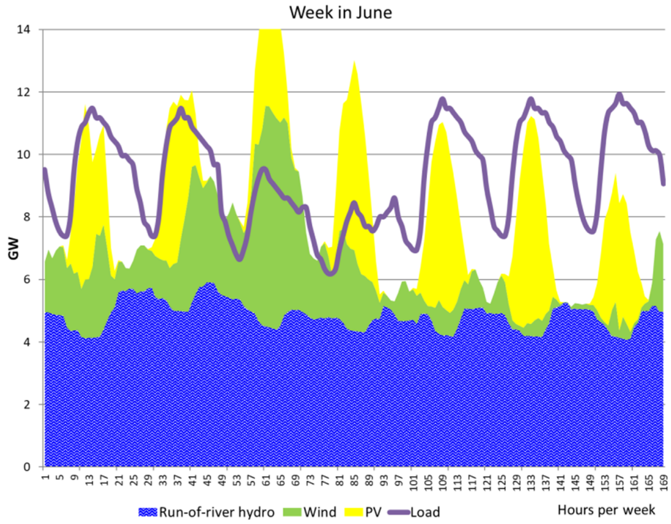

Fig. 8. Modeling variable renewable energy sources and, electricity load during a week in June 2030 in Austria (Source: own analysis, adapted from [3]).

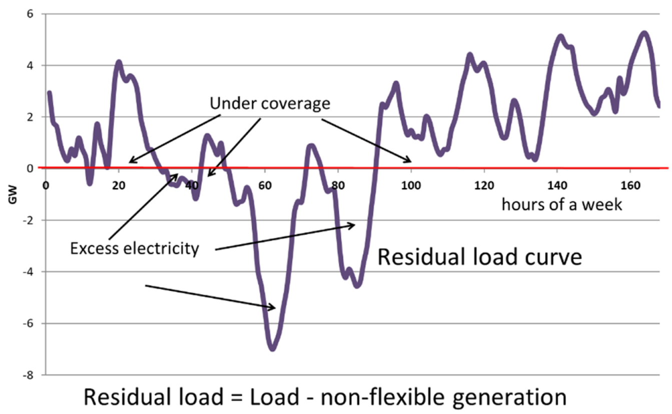

Fig. 9. The residual load curve referring to Figure 8 representing the difference between total load and the aggregate of VRES.

Furthermore, with respect to the design of the markets, more flexibility is required: To better integrate VRES in the electricity system the time intervals in markets have to be shortened reduced (shorter trading intervals, more relevance of the intraday markets, less leading times ahead of clearing the wholesale markets and reducing the forecasting period of VRES electricity generation).

Yet, most important to even out differences in residual load is to introduce a cost-minimal portfolio of flexibility opportunities which are available in principle already today. A very comprehensive survey and an excellent review of flexibility options in the electricity system to make high quantities of VRES in this system possible is documented by [26]. However, today these measures are not fully harvested because of non-existing proper financial incentives, see above.

Major flexibility options to meet residual load are:

- Short as well as long-term options of storage as e.g. pumped hydro, batteries, or chemical options such as methane and hydrogen.
- Smart grids: They make possible to switch the load between different voltage levels and provide a contribution to the balancing of residual load.
- Coordinating entities such as balancing groups will play a key role in this new concept. They are the organization units that finally will balance generation, flexibilities as well as demand options by means of contracts.

6 The role of energy communities

The developments of PV system use also imply certain needs for adaption in the given market environment. One of the most promising applications is the distributed use and trade with PV electricity "behind the meter". Such a solution requires appropriate data management for pricing, the monitoring of transactions and data storage for such distributed installations. Figure 10 illustrates the idea of a tenant electricity model linked to a data management tool which could change the overall electricity system considerably and add to the transparency and control capabilities. This could be of risiing relevance given the increasing number of individuals, households and also other consumers such as supermarkets that are no more pure electricity customers but have increasingly changed to small electricity producers and may in addition also store the electricity they generated ("pro-sum-agers").

In the situation shown in the figure, the tenants or the landlord no longer purchases electricity as the average final customer. They become electricity resellers. Unintended or not, the electricity supplier becomes a wholesale supplier. A metering system at each of the tenants could track the transactions and provide for appropriate pricing. The distributed grid of electricity consumers and producers is depicted within the data management tool. By tagging and tracking every event and interaction, this technology could help to accelerate innovation in integrating the digital world with the energy system.

7 A new thinking approach for the further evolution of the electricity systems

In addition to the issue of rising shares of VRES there are some principles that should be implemented to improve the overall structure of the market and rise competitiveness fundamentally. As completions to updated and revised EOM some of these measures are:

- For forecasting VRES generation as well as for market clearing the leading times should be shorter.
- More flexibility options in the wholesale and retail market are necessary.
- In general long term contracts have to become available especially also for time periods higher than six years and carefully adapted to the market needs.

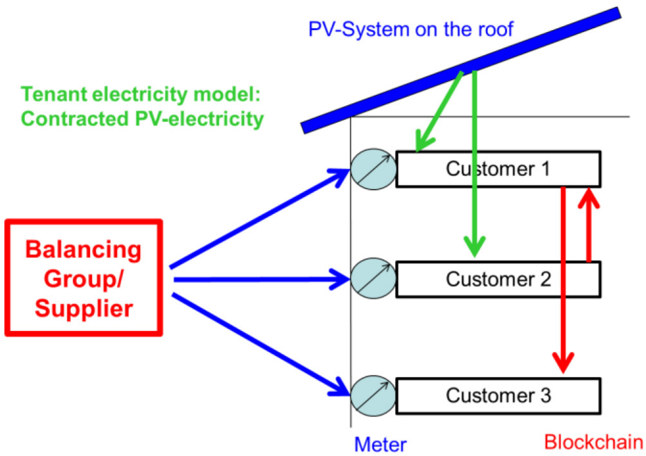

Fig. 10. Data management tools to coordinate transactions for distributed electricity customers in an apartment building.

Finally, it has to be stated that a transition towards a more democratic as well as sustainable electricity system of the future where also customers have the opportunity to compete will rely on principles of a "new thinking approach". This means that the fundamental structures of the overall electricity system will change. It will be based on changing from the old inflexible one-way elecricity delivery system to a very flexible one with a two or multi-way flow of electricity and a much broader scope for increasing demand-side activities by the aldready mentioned so-called "prosumagers" (= electricity consumers which in addition produce and store electricity). Furthermore, coordinating entities such as balancing groups will become an increasingly important part of the system finally providing the energy services see Figure 11.

As indicated in Figure 11 decentralized PV systems together with small batteries could play a very important role in the near future. There seems to be a general understanding that the fall in production costs of electricity from VRES linked to the expected decline in electricity storage costs will accelerate the transition towards a sustainable power sector.

Regarding the case study of the Austrian electricity system the major finding is that up to 2030 RES can contribute to electricity generation to the same extent as electricity demand is expected to be. This implies a growth to 16 TWh Wind (in 2020: 7 TWh) and 10 TWh PV (in 2020: 1TWh). However, to meet demand on an hourly base over the whole year even after having implemented additional storage capacities and several flexibility measures on the demand-side an amount of about 2 TWh electricity (compared to 10 TWh in 2020) has to be generated from different gas-based power plants (e.g. natural or biomass-based gases).

8 Conclusions

The most important conclusion from the literature investigated is that the sustainable deployment of high quantities of VRES production is possible by conducting a redesign of the current market structures. An important aspect is that the re-design has to take place on the supply-side (flexible back-up capacity) as well as on the demand-side (regulatory incentives and new tariff structures). Regarding the need for new tariff systems, the request for additional storage, the integration of the demand-side options and the extended use of flexibility measures virtually all papers come to the conclusion that these measures have to be put into practice not only to accommodate larges shares of VRES but to head for complete electricity markets where also customers have the opportunity to compete. with respect to the impact of VRES on the wholesale electricity market prices there is consensus that in Europe between about 2012 to 2016 the increase in PV and wind capacities has led to decreasing prices, however, this issue is highly dependent on the availability of VRES (including hydro power), the increase of electricity demand but also the prices of fossile fuels, especially of natural gas. The setting up of an entity coordinating the contracts with suppliers and consumers has low priority in general in the discussion but is called for by Tsaousoglou [7] and [14]. The most controversial point in the literature is the call for capacity payments to ensure resource adequacy. Praktiknjo [14] brings it to the clear point that subsidizing both, new VRES and old conventional capacity cannot go along with the idea of a liberalized market.

The major conclusions of this analysis are:

- Today in real life more and more citizens state their interest in becoming more and more self-suppliers and participating actively in the system. This process is currently under way in several countries such as Germany, Austria, Denmark, California, Australia and others where also changes in the way how prices are formed are expected.
- As already mentioned it is emphasized that the transition to a more democratic as well as sustainable electricity system of the future where also customers have the opportunity to to compete will rely on principles of a "new thinking approach". This means that the fundamental structures of the overall electricity system will change. It will be based on changing from the old inflexible one-way elecricity delivery system to a very flexible one with a two or multi-way flow of electricity This also allows for a broader portfolio of storage systems, demand-side options and additional flexibility measures.
- Most important for heading towards a democratic sustainable electricity supply is the broad exhaustion of flexibility options based on price signals as correct as possible on the wholesale level and at the final customers level. However, currently on the wholesale as well as on the retail market the price signals for the market participants are no "correct" and do not ensure incentives for sufficient flexibility activities (e.g. long and short-term storage, customers response in demand due to correct prices, technical DSM measures,) which could provide contributions to even out demand profiles and supply curves in an elegant and much more effictent mode.

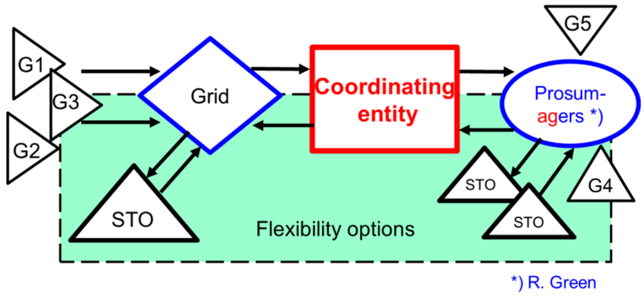

Fig. 11. The principle of "New thinking" in restructuring the electricity systems: from one-way delivery chains to multi- way flow – oriented systems with broad varieties of flexibility options.

– It is important to recognize that the VRES cannot be forced into the system just using technical measures. The appropriate incentives from economic point-of-view are required to make it happen. In a revised electricity market of the future price signals as correct as possible consisting of scarcity and excess pricing components are necessary. The only "negative" sign of such a market excluding capacity payments would be that, in the short term, prices lower or above the marginal costs may happen. In the course of the time the market places would adapt to these volatilities and finally benefit from these changes in the price spreads.

An outlook has to consider especially that it is important to differ between short-term and long-term decisions in the system. While in the short-term, market-based mechanisms are a very useful, efficient and elegant tool, it is different in the long run. Here, the markets alone will not make it, it is also important that regulatory boundary conditions have to be set, especially for long-term investment perspectives. With respect to the design of the markets, more flexibility is required which is expected to be implemented stepwise in the next years. However this will be possible, only if the proper price incentives and tariff structures are implemented. To better integrate VRES in the market also the time intervals in the wholesale markets have to be reduced (i.e. more emphasis on intraday markets, shorter trading intervals and shorter forecasting times regarding hydro, wind and solar). The final conclusion is that the development of such a flexible way to integrate VRES in the Austrian electricity system – and simultanuously in other countries – would also serve as a role model for largely renewable-based electricity systems all over the world.

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Cite this article as: Reinhard Haas, Hans Auer, Gustav Resch, Heading towards democratic and sustainable electricity systems – the example of Austria, Renew. Energy Environ. Sustain. **7**, 20 (2022)